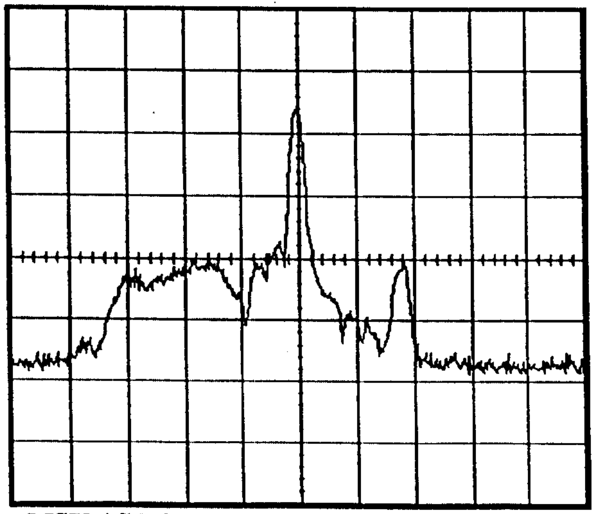
COMMENTS:

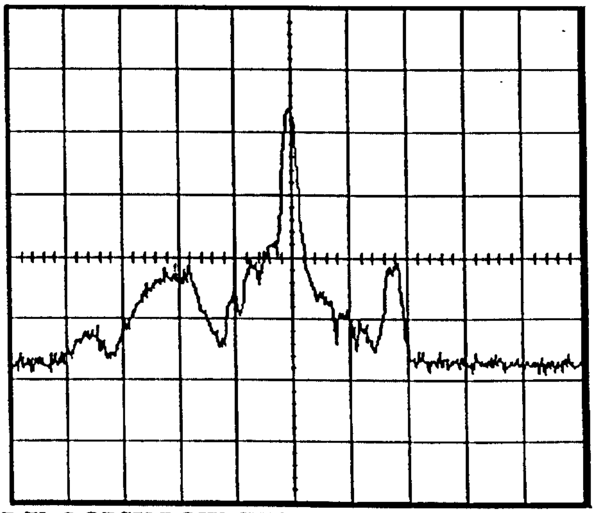
1. The maximum desired to undesired ratio was determined with the maximum signal out from the ITFS DDM or at 0 ATTN. This was, as with the REF F study, the ratio of the maximum Video peak power output to the total digital channel output. In our case, using 30 Khz IF bandwidth on the Spectrum Analyzer, a D/U=1 or 0 dB would be when the wideband digital signal was 23 dB below the peak TV video signal
2. The spectral plot for the D/U=0 for wideband MSK as a lower channel interference signal is shown in 3.4.1.2.1 A.
3. TOV was determined with a color bar pattern.
4. Undesired signal power was increased 6 dB making the interference CCIR 4
5. The spectral plot for the D/U=+5 for wideband QPSK as a lower channel interference signal is shown in 3.4.1.2.1 B.
6. The spectral plot for the D/U=-17 for a single narrowband MSK or D/U=-3 for a full bandwidth of narrowband signals as a lower channel interference signal is shown in 3.4.1.2.1 C.. The Narrowband interfering signal is located next – about 200 Khz- to the lower channel boundary of the desired signal.
7. These configurations were tested in a wireline configuration.
8. The spectral plot for the D/U=+5 for wideband QPSK as a lower channel interference signal is shown in 3.4.1.2.1 D.
9. The spectral plot for the D/U=-17 for a single narrowband MSK or D/U=-3 for a full bandwidth of narrowband signals as a lower channel interference signal is shown in 3.4.1.2.1 E. The Narrowband interfering signal is located next – about 200 Khz- to the lower channel boundary of the desired signal.
10. The spectral plot for the D/U=+5 for narrowband QPSK as a lower channel interference signal is shown in 3.4.1.2.1 F. The Narrowband interfering signal is located about 200 Khz to the lower channel boundary of the desired signal.

V=10 dB/ SPAN 20 Mhz RES BW 30K
↓ +17 dBm CENTER VBW 10 Khz

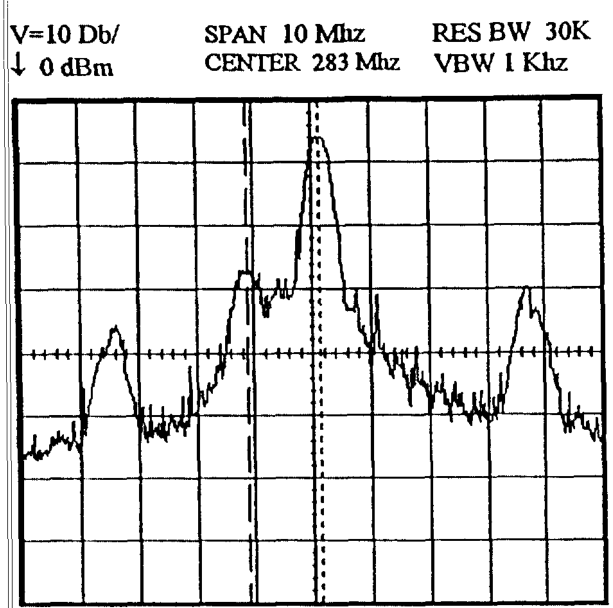


MSK AS LOW CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.1 A

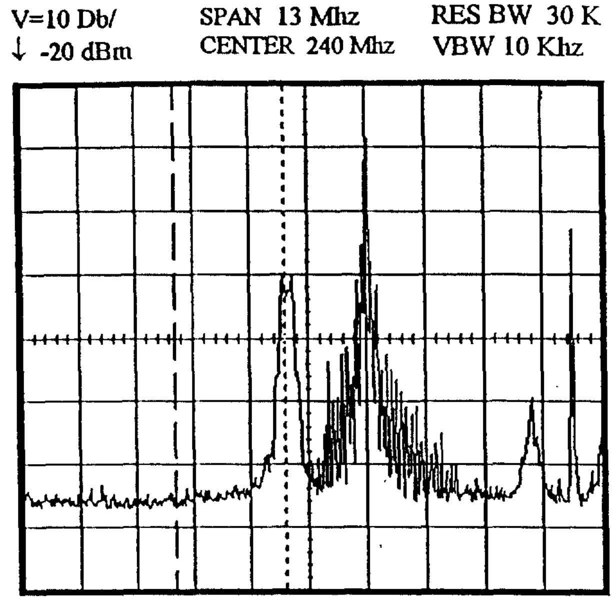
V=10 dB/ SPAN 20 Mhz RES BW 30K
↓ +17 dBm CENTER VBW 10 Khz



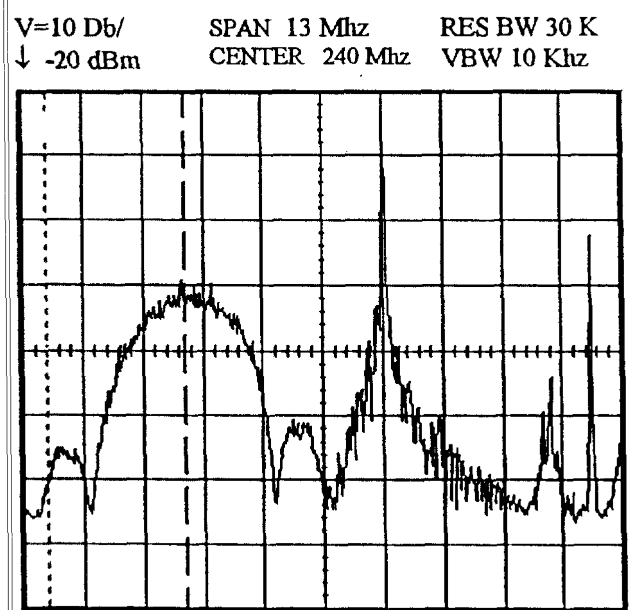
D/U=5 QPSK LOW CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.1 B



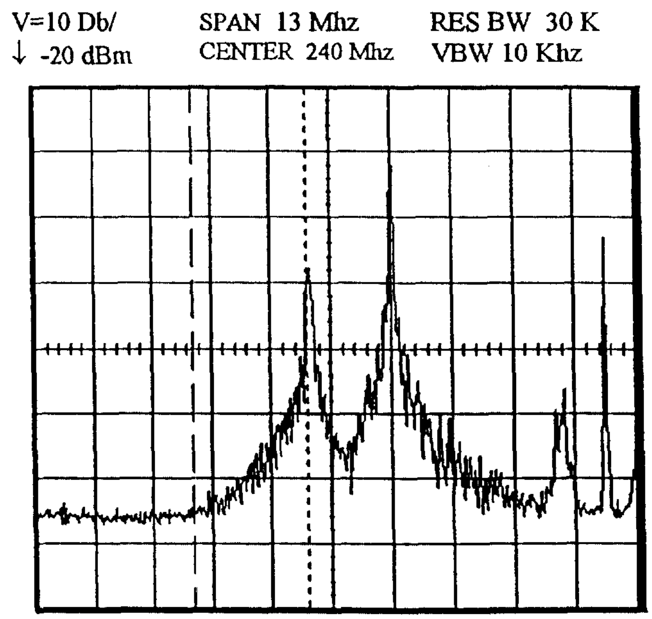
**MSK NB AS LOW CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.1 C**



**QPSK WB AS LOW CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.1 D**



**MSK NB AS LOW CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.1 E**



**QPSK NB AS LOW CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.1 F**

3.4.1.2.2 Upper Channel Digital to TV Interference

In order to create upper channel interference for the desired TV signal the ITFS DDM was tuned to 38 Mhz- one channel lower (this becomes the upper channel out of the RF Transmitter)-than the normal 44 Mhz output. D/U ratios are established by attenuation of the undesired signal. Test results follow.

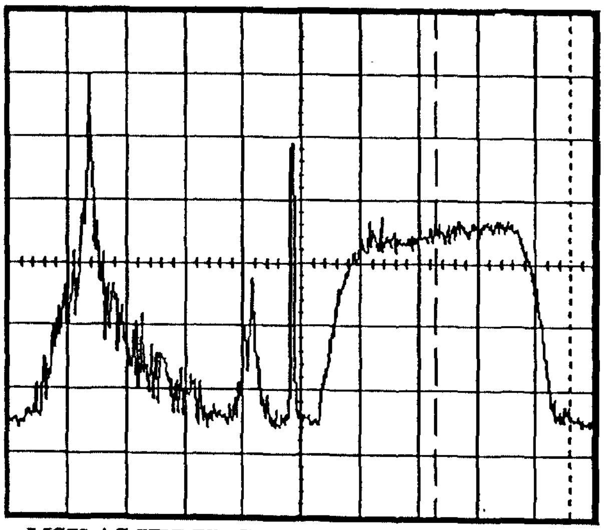
TABLE 3.4.1.2.2 Upper Channel Interference - Digital onto TV

WEATHER N/A			CHANNEL -		TIME AM(9-12)	
			EIRP=-		PACE Mania/Perri (IR)	
			DATE 5/26/98		SRI Howe/Queen (IR)	

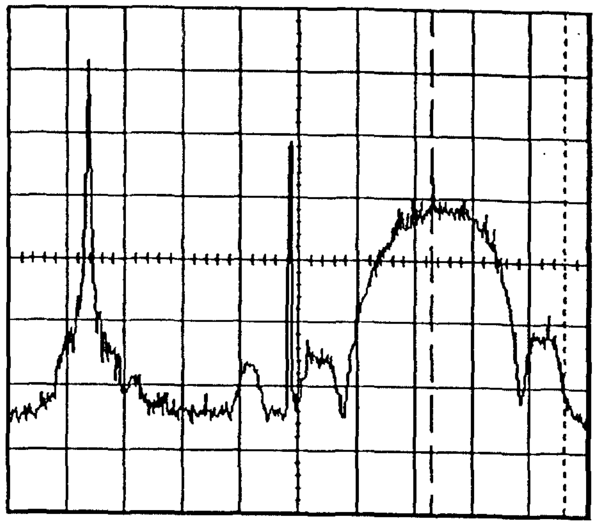
TEST PLAN PARAGRAPH	DES-IRED	UNDESIRED SIGNAL	ATTN	D/U RATIO	RESULTS	COMMENTS
4.4.4.4.1I	TV	4Mbps/MSK		0		1,2
4.4.4.4.1I	TV	4Mbps/MSK	-3	<-10	TOV	3
4.4.4.4.1J'	TV	4Mbps/QPSK	5	0		4
4.4.4.4.1J'	TV	4Mbps/QPSK		-10	TOV	3
4.4.4.4.2E	TV	250Kbps/MSK		0		5
4.4.4.4.2E	TV	250Kbps/MSK		<-5	TOV	3
4.4.4.4.2F'	TV	250Kbps/QPSK	-	0		6
4.4.4.4.2F'	TV	250Kbps/QPSK		-1	TOV	3
4.4.4.4.2G	TV	250Kbps/MSK		<-10	TOA	7
4.4.4.4.2H'	TV	250Kbps/QPSK		<-10	TOA	7

COMMENTS:

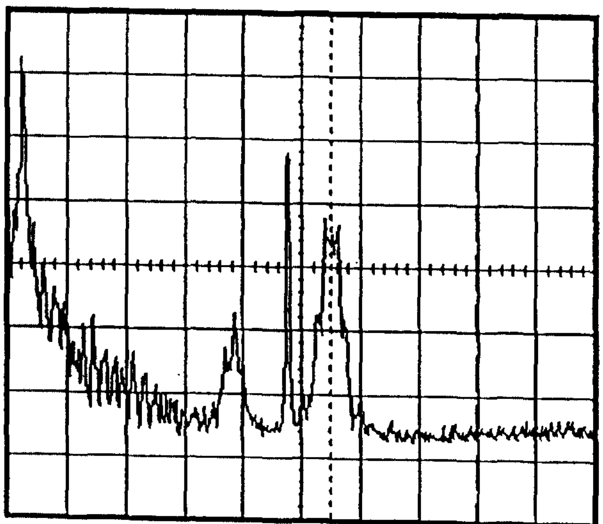
1. The maximum desired to undesired ratio was determined with the maximum signal out from the ITFS DDM or at 0 ATTN. This was, as with the REF F study, the ratio of the maximum Video peak power output to the total digital channel output. In our case, using 30 Khz IF bandwidth on the Spectrum Analyzer, a D/U=1 or 0 dB would be when the wideband digital signal was 23 dB below the peak TV video signal. Also, the Visual detection process of obtaining TOV was changed from turning the Transmitter input On-Off-On-Off to turning the Modulator input to On-Off-On-Off so as to avoid the transmitter transition caused by the latter.
2. The spectral plot for the D/U=0 for wideband MSK as an upper channel interference signal is shown in 3.4.1.2.2 A.
3. TOV was determined with a color bar pattern.
4. The spectral plot for the D/U=+5 for wideband QPSK as an upper channel interference signal is shown in 3.4.1.2.2 B.
5. The spectral plot for the D/U=-14 for a single narrowband MSK or D/U=0 for a full bandwidth of narrowband signals as an upper channel interference signal is shown in 3.4.1.2.2 C. The Narrowband interfering signal is located next – about 200 Khz- to the upper channel boundary of the desired signal
6. The spectral plot for the D/U=-14 for a single narrowband QPSK or D/U=0 for a full bandwidth of narrowband signals as an upper channel interference signal is shown in 3.4.1.2.2 D. The Narrowband interfering signal is located next –about 200 Khz- to the upper channel boundary of the desired signal
7. Never did hear the audio interference.



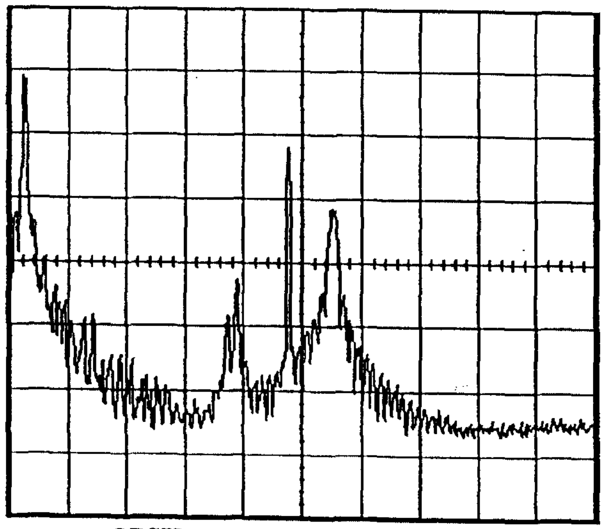
MSK AS UPPER CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.1.2.2 A



QPSK AS UPPER CHANNEL INTERFERENCE
SPECTRAL PLOT 3.4 .1.2.2 B



MSK NB AS UPPER CHANNEL
INTERFERENCE
SPECTRAL PLOT 3.4.1.2.2 C



QPSK NB AS UPPER CHANNEL
INTERFERENCE
SPECTRAL PLOT 3.4.1.2.2 D

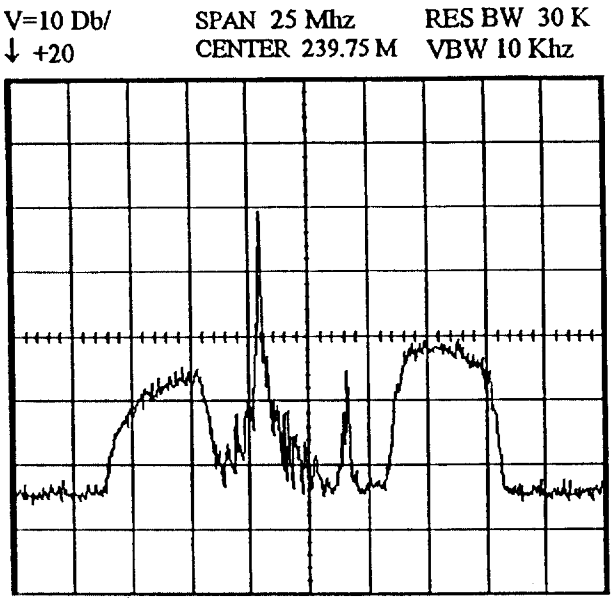
3.4.1.2.3 Upper/Lower Channel Digital to TV Interference

In order to create upper/lower channel interference for the desired TV signal the ITFS DDM was tuned to 38 Mhz. Its output was upconverted to 50 Mhz and summed with the 38 Mhz signal in the custom SRI up/down converter/summer equipment. This left one ITFS channel in between the two digital channels. This combined signal was input to the A2 transmitter just as a single channel was in the previous two paragraphs. Test results follow

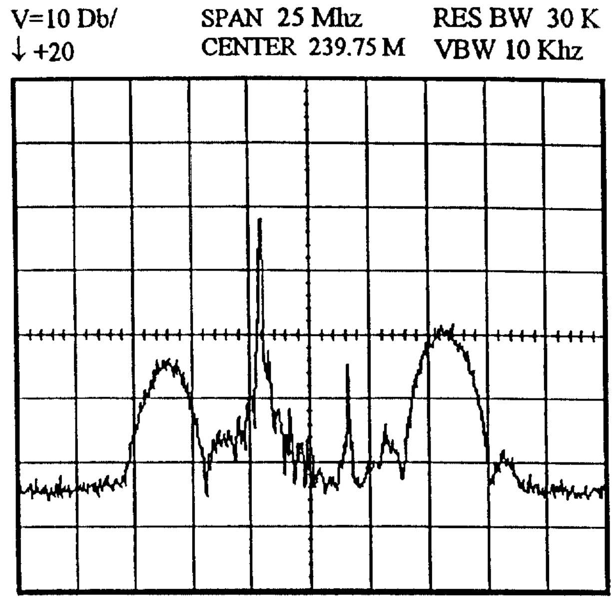
TABLE 3.4.1.2.3 Upper/Lower Channel Interference - Digital onto TV						
WEATHER N/A			CHANNEL A2		TIME AM(9-12)	
			POWER =44		PACE Mania/Perri (IR)	
			DATE 5/28/98		SRI Howe/Queen (IR)	
TEST PLAN PARAGRAPH	DES-IRED	UNDESIRED SIGNAL	ATTN	D/U RATIO	RESULTS	COMMENTS
4.4.4.4.1M	TV	4Mbps/MSK		-1	TOV	1,2
4.4.4.4.1M	TV	4Mbps/MSK		-7	CCIR4	3
4.4.4.4.1N'	TV	4Mbps/QPSK		-2	TOV	4
4.4.4.4.1N'	TV	4Mbps/QPSK		-8	CCIR4	3
4.4.4.4.1P	TV	4Mbps/MSK		<-8	TOA	5,6
4.4.4.4.1O	TV	4Mbps/QPSK		<-5	TOA	5,7

COMMENTS:

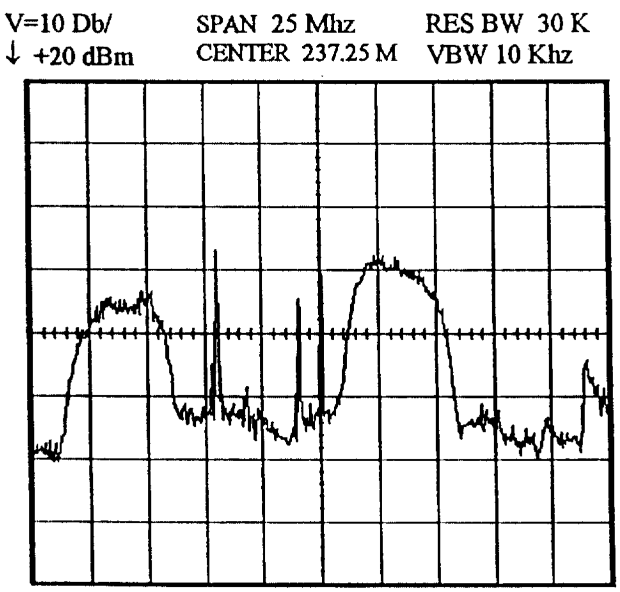
1. The maximum desired to undesired ratio was determined with the maximum signal out from the ITFS DDM or at 0 ATTN. This was, as with the REF F study, the ratio of the maximum Video peak power output to the total digital channel output. In our case, using 30 Khz IF bandwidth on the Spectrum Analyzer, a D/U=1 or 0 dB would be when the wideband digital signal was 23 dB below the peak TV video signal. Also, the Visual detection process of obtaining TOV was changed from turning the Transmitter input On-Off-On-Off to turning the Modulator input to On-Off-On-Off so as to avoid the transmitter transition caused by the latter.
2. The spectral plot for the D/U=TOV for wideband MSK as an upper/lower channel interference signal is shown in 3.4.1.2.3 A.
3. At TOV +6dB the level of interference was CCIR4.
4. The spectral plot for the D/U=TOV for wideband QPSK as an upper/lower channel interference signal is shown in 3.4.1.2.3 B.
5. For this test sequence, composite Video (Video +Aural) was input to the VIS of the transmitter.
6. The spectral plot for the D/U=TOA for a wideband MSK upper/lower channel interference signal is shown in 3.4.1.2.3 C.
7. The spectral plot for the D/U=TOA for a wideband QPSK upper/lower channel interference signal is shown in 3.4.1.2.3 D.



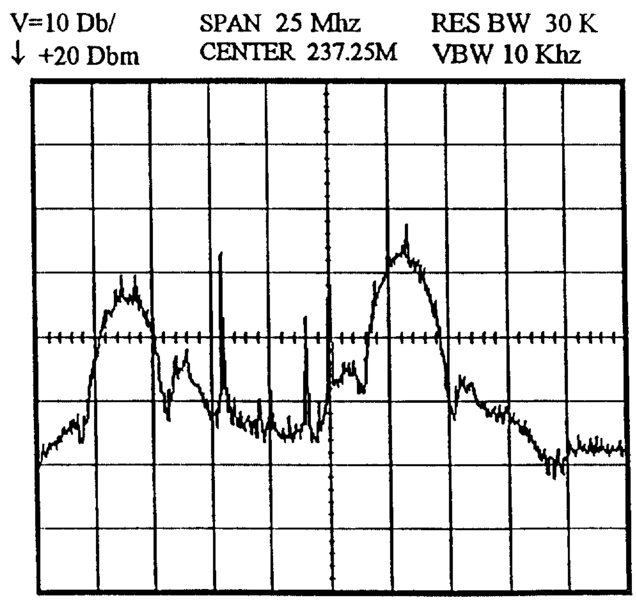
MSK AS UPPER /LOWER
TOV INTERFERENCE
SPECTRAL PLOT 3.4.1.2.3 A



QPSK AS UPPER/LOWER
TOV INTERFERENCE
SPECTRAL PLOT 3.4 .1.2.3 B



MSK AS UPPER /LOWER
TOA INTERFERENCE
SPECTRAL PLOT 3.4.1.2.3 C



QPSK N AS UPPER/LOWER
TOA INTERFERENCE
SPECTRAL PLOT 3.4.1.2.3 D

3.4.2 TV onto Digital Interference

Please note that for this testing the desired (D) signal is the digital signal and the undesired (U) signal is the TV. Due to system constraints the methods of generating the interference was different for co-channel and adjacent testing. The methods will be discussed in the applicable paragraph.

3.4.2.1 Co-Channel TV to Digital Interference

Co- channel TV onto Digital interference testing was accomplished on the Bear Creek to Wolverine Link. In order to create co-channel TV to Digital interference, the ITFS DDM was configured to transmit at 44 Mhz. which would put the Digital and Video on the same frequencies. The Desired (D) digital input signal was developed by the ITFS DDM Modulator and inputted to the VIS channel of the C2 Transmitter with maximum digital power output (+25% of full power). The Undesired (U) video signal was on Channel C2 with the AUR input as the Video signal input (The Video signal was attenuated by 20 dB so as not to overload the AUR channel). This channel was fully operational and with a power output that would create a D/U ratio of 30 dB with full Digital power on the VIR channel. The video transmitted was a color bar test pattern. The test pattern was on a high quality VCR which drove a standard PACE TV Modulator which was input to the C2 AUR input at Bear Creek.. The level of desired/undesired (D/U) was established by attenuators. The BER was used as the measure of interference caused by the TV onto the transmitted digital data. Test results follow:

TABLE 3.4.2.1 Co-Channel Interference - TV onto Digital

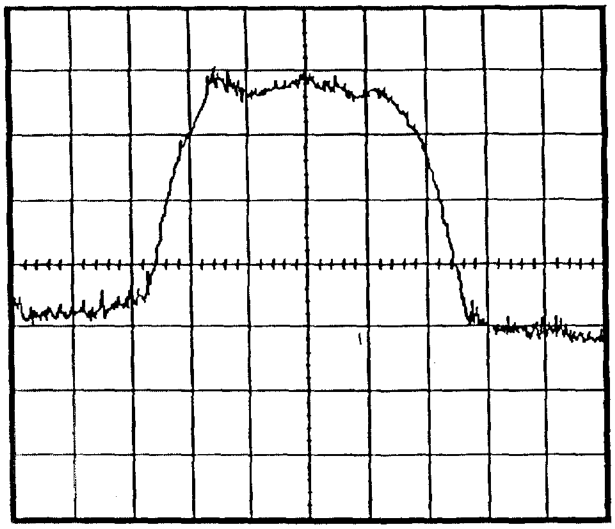
WEATHER CLEAR AND WARM		
	CHANNEL C2	TIME AM(9-12)
	EIRP=+63Dbm	PACE Mania/Perri (BC/W)
	DATE 5/20	SRI Howe/Queen (BC/W)

TEST PLAN PARAGRAPH	DESIRED SIGNAL	UNDESIRED SIGNAL	ATTN	D/U RATIO	RESULTS BER	COMMENTS
4.4.4.4.3A	4Mbps/MSK	TV-V	-	>40	2E-07	1
4.4.4.4.3A	4Mbps/MSK	TV-V	0	30	5E-06	2,3
4.4.4.4.3A	4Mbps/MSK	TV-V	1	29	8E-06	
4.4.4.4.3A	4Mbps/MSK	TV-V	2	28	1E-05	
4.4.4.4.3A	4Mbps/MSK	TV-V	3	27	5E-05	
4.4.4.4.3A	4Mbps/MSK	TV-V	4	26	2E-04	
4.4.4.4.3A	4Mbps/MSK	TV-V	5	25	-	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	-	>40	<0E-8	1
4.4.4.4.3B	4Mbps/OQPSK	TV-V	0	30	<0E-8	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	5	25	<0E-8	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	7	23	<0E-8	4
4.4.4.4.3B	4Mbps/OQPSK	TV-V	10	20	<0E-8	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	11	19	<0E-8	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	12	18	<0E-8	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	13	17	<0E-8	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	14	16	1E-06	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	15	15	2E-05	
4.4.4.4.3B	4Mbps/OQPSK	TV-V	16	14	8E-04	
4.4.4.4.3B	4Mbps/QPSK	TV-V	-	>40	<0E-8	
4.4.4.4.3B	4Mbps/QPSK	TV-V	13	17	<0E-8	
4.4.4.4.3B	4Mbps/QPSK	TV-V	16	14	7E-05	
4.4.4.4.4A	128Kbps/MSK	TV-V		37	<0E-06	5
4.4.4.4.4A	128Kbps/MSK	TV-V		37	<0E-06	6,7
4.4.4.4.4A	128Kbps/MSK	TV-V		37	1E-06	8
4.4.4.4.4A	128Kbps/MSK	TV-V		32	2E-04	8
4.4.4.4.4A	128Kbps/MSK	TV-V		27	1E-02	8
4.4.4.4.4A	128Kbps/MSK	TV-V		17	1E-01	8
4.4.4.4.4B	128Kbps/QPSK	TV-V		37	>0E-07	9,10
4.4.4.4.4B	128Kbps/QPSK	TV-V		37	>0E-07	11,12
4.4.4.4.4B	128Kbps/QPSK	TV-V		37	>0E-07	13,14
4.4.4.4.4B	128Kbps/QPSK	TV-V		42	>0E-07	15
4.4.4.4.4B	128Kbps/QPSK	TV-V		37	>0E-07	15
4.4.4.4.4B	128Kbps/QPSK	TV-V		32	>0E-06	15
4.4.4.4.4B	128Kbps/QPSK	TV-V		27	NO SYNC	15

COMMENTS:

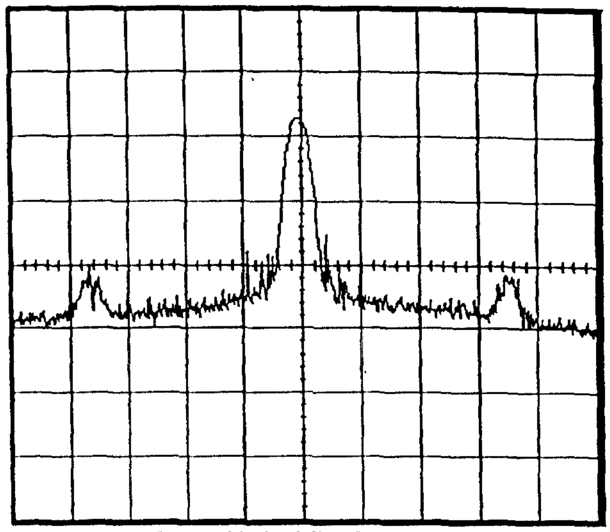
1. The maximum desired to undesired ratio was determined with the TV signal not being an input and this was listed as >40 dB. The baseline D/U was established with the TV Video signal relationship to the digital signal, as with the REF F study - the ratio of the maximum Video peak power output to the total digital channel output. In our case, using 30 Khz IF bandwidth on the Spectrum Analyzer, a D/U=1 or 0 dB would be when the digital signal was 23 dB below the peak TV video signal. In this case the TV Video signal was attenuated 20 dB and input to the AUR where it is attenuated another 10 dB. In this case the undesired TV was attenuated 30 dB for a D/U=30. For reduced D/U the desired signal was reduced by an ATTN.
2. The spectral plot for the desired data (MSK) with D/U=30 is 3.4.2.1 A.
3. The spectral plot for the Video interfering signal for D/U=30 is3.4.2.1 B. That is this plot is the hidden interfering signal from 3.4.2.1 A.
4. The spectral plot for D/U=23 for OQPSK is 3.4.2.1 C.
5. This measurement is with a MSK signal offset about 600 Khz from the Video carrier. The D/U for the narrowband digital signals is calculated on the same spectral density as a wideband digital signal. In this case it is D/U= 37 dB. To adjust to a D/U based upon full digital power in the narrow bandwidth adjust D/U down by about 14 dB or D/U=23.
6. This measurement is with a MSK signal offset about 256 Khz from the Video carrier. The D/U for this is D/U= 37 dB.
7. The spectral plot 3.4.2.1 D for the TV color carrier 256Khz below the narrowband MSK signal at the D/U of D/U= 37dB.
8. This is for the case when the interfering carrier is at the same frequency of the MSK signal.
9. This is the case of the 128Kbps QPSK being in the middle of the TV channel or about 1.75 from the video carrier.
10. This is the spectral plot 3.4.2.1 E of the 128Kbps QPSK being in the middle of the TV channel
11. This is the case of the 128Kbps QPSK being about 500 Khz from the video carrier.
12. This is the spectral plot 3.4.2.1 F of the 128Kbps QPSK being about 500 Khz from the Video carrier.
13. This is the case of the 128Kbps QPSK being about 256 Khz from the video carrier.
14. This is the spectral plot 3.4.2.1 G of the 128Kbps QPSK being about 256 Khz from the Video carrier.
15. This s the case of the 128Kbps QPSK being on about the same frequency of the video carrier.

V=10 Db/ SPAN 40 Mhz CENTER RES BW 30K VBW 10 Khz



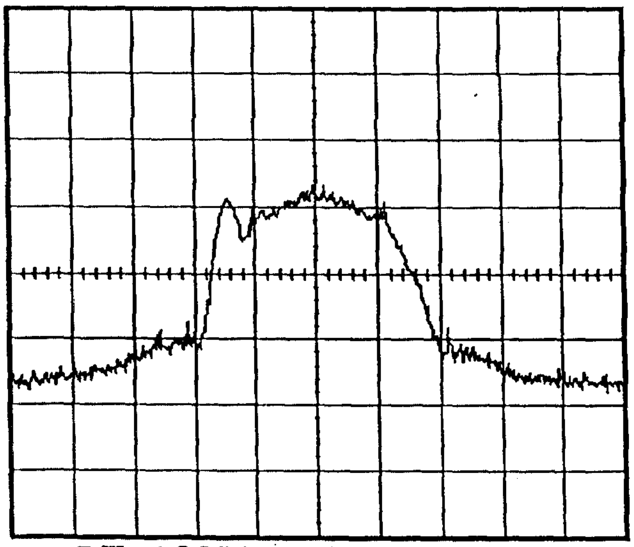
MSK D/U=30
SPECTRAL PLOT 3.4.2.1 A

V=10 Db/ ↓ SPAN 10 Mhz CENTER RES BW VBW



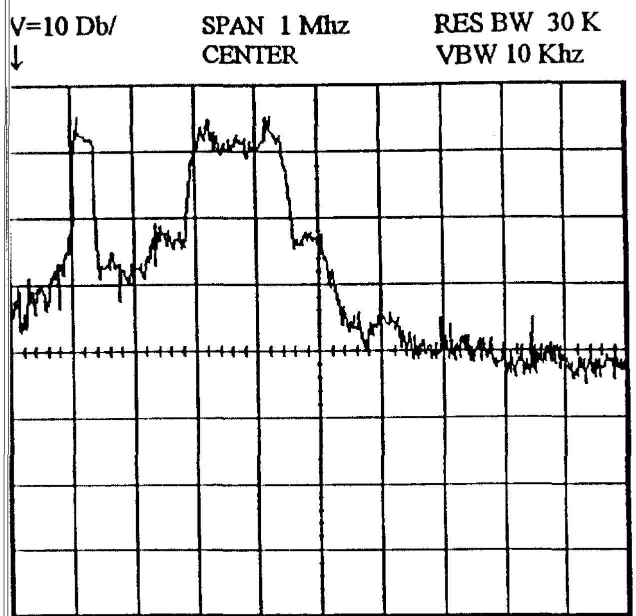
TV (VIDEO) AS COCHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.2.1 B

V=10 Db/ ↓ SPAN 10 Mhz CENTER RES BW 30K VBW 10 Khz

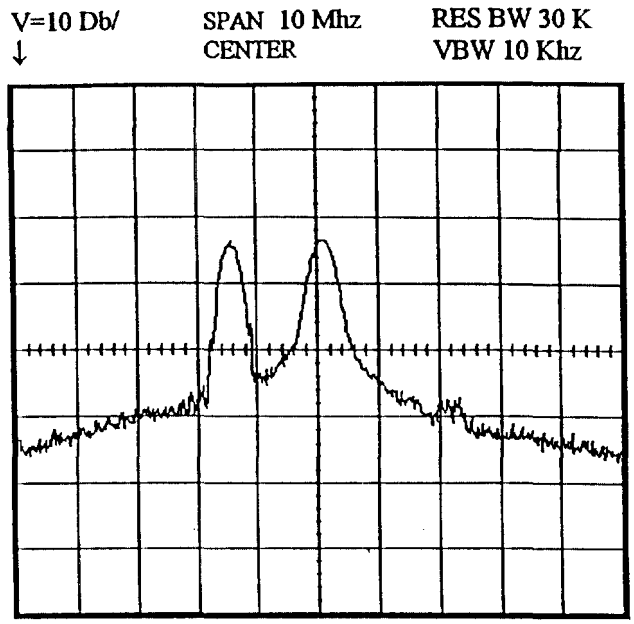


D/U=23 OQSK WITH TV COCHANNEL INTERFERENCE
SPECTRAL PLOT 3.4.2.1 C

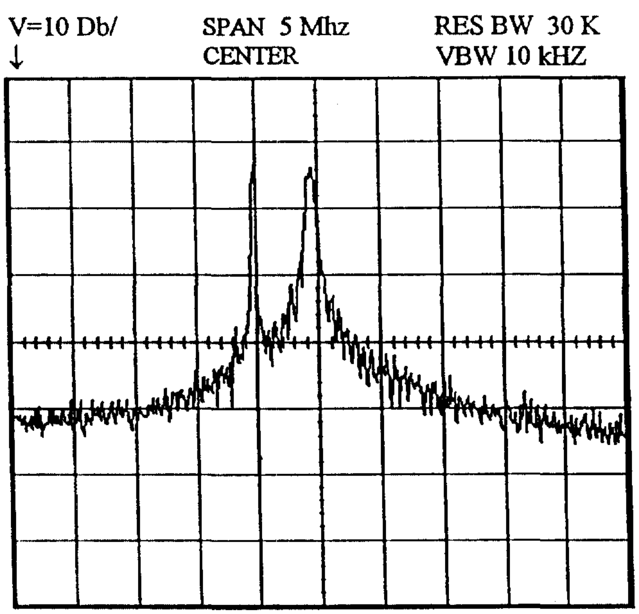
There is no spectral plot in this location.



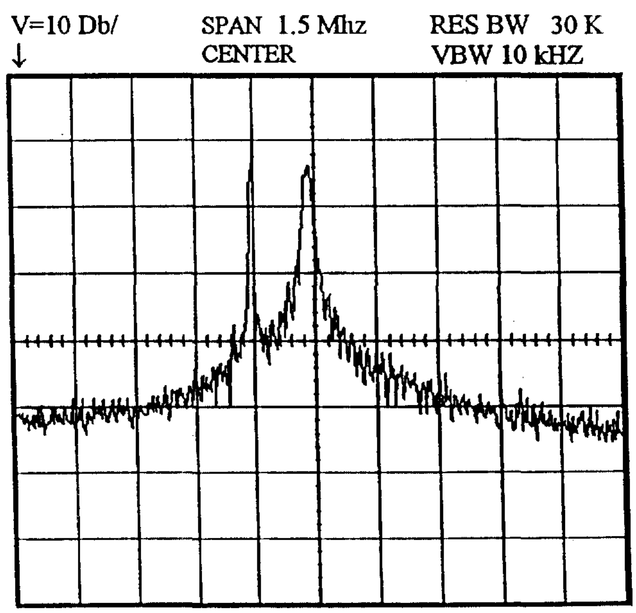
D/U=37 MSK NB DATA WITH TV (COLOR CARRIER VISIBLE) INTERFERENCE SPECTRAL PLOT 3.4.2.1 D



NB QPSK IN CENTER OF CHANNEL TV VIDEO CARRIER TO THE RIGHT SPECTRAL PLOT 3.4 .2.1 E



NB QPSK 500 KHZ FROM VIDEO CARRIER SPECTRAL PLOT 3.4.2.1 F



NB QPSK 5256 KHZ FROM VIDEO CARRIER SPECTRAL PLOT 3.4.2.1 G

3.4.2.2 Adjacent Channel TV to Digital Interference

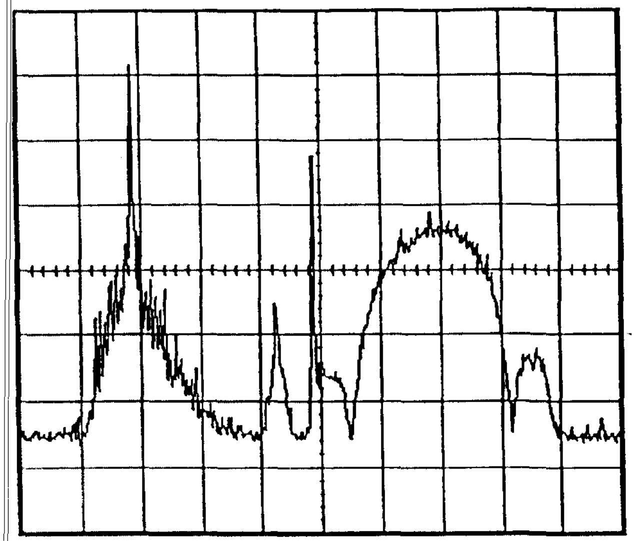
The scenario of a strong interfering TV signal on the adjacent lower or upper channel to the Desired (D) digital data is documented below.

For this interference scenario, the desired digital signal was transmitted from PACE on Channel A2 and received locally at PACE. The downconverted digital signal was summed with an undesired TV signal from a PACE inventory ITFS Modulator and upconverted (Agile Channel). The upconverted TV output was placed in the channel above or below the downconverted digital data signal. Atteunators were used to adjust for the desired D/U ration. BER was used as the measure of interference. Test results are on the following page. Comments on these test results are below.

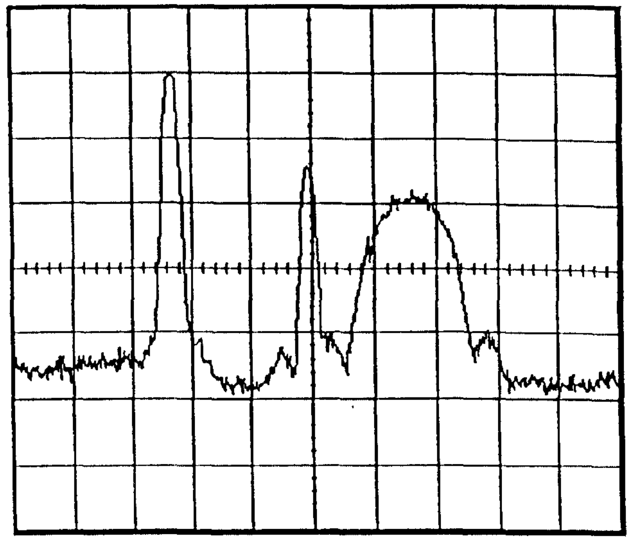
COMMENTS to Table 3.4.2.2:

1. The maximum desired to undesired ratio was determined with the TV signal not being an input and this was listed as >40 dB. The baseline D/U was established with the TV Video signal relationship to the digital signal, as with the REF F study - the ratio of the maximum Video peak power output to the total digital channel output. In our case, using 30 Khz IF bandwidth on the Spectrum Analyzer, a D/U=1 or 0 dB would be when the digital signal was 23 dB below the peak TV video signal.
2. Viterbi encoding of the digital data was used in some cases.
3. The spectral plot for D/U=0 for QPSK is 3.4.2.2 A.
4. The spectral plot for D/U=0 for QPSK is 3.4.2.2 B Both the desired and undesired signal have been reduced by 10 dB. D/U is still zero.
5. This was a second QPSK test.
6. This was a narrowband signal near the upper channel border for the desired signal. The TV video carrier (+23 dB) is about 1.5 Mhz away. See spectrum plot 3.4.2.2 C. This narrowband data signal at the same power spectral density of a wideband digital signal and reflected the D/U=0 for the wideband case. In reality only one narrowband signal would have a D/U of 14 (250Khz/6 Mhz) instead of 0 if the narrowband signal was at the same power level of a wideband signal. Using this the no error situation would be at D/U=>-6 which is close to the wideband situation.
7. This was a narrowband signal near the lower channel border for the desired signal. The TV audio carrier (+8 dB) is about 0.5 Mhz away. See spectrum plot 3.4.2.2 D. Amplitude considerations are the same as in note 6 above.

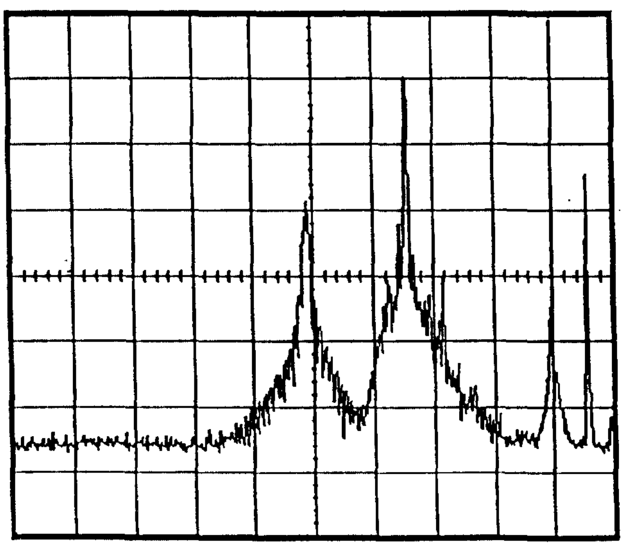
TABLE 3.4.2.2 Adjacent Channel Interference - TV onto Digital						
WEATHER CLEAR AND WARM			CHANNEL C2		TIME AM(9-12)	
			EIRP=+63Dbm		PACE Mania/Perri (BC/W)	
			DATE 5/20		SRI Howe/Queen (BC/W)	
TEST PLAN PARAGRAPH	DESIRED SIGNAL	UNDESIRED SIGNAL	ENCODE	D/U RATIO	RESULTS BER	COMMENTS
4.4.4.4.3E	4Mbps/MSK	TV-V	N	0	5E-02	1
4.4.4.4.3E	4Mbps/MSK	TV-V	N	40	4E-07	
4.4.4.4.3E	4Mbps/MSK	TV-V	Y	40	<0E-08	2
4.4.4.4.3E	4Mbps/MSK	TV-V	N	30	2E-06	
4.4.4.4.3E	4Mbps/MSK	TV-V	Y	30	<0E-08	
4.4.4.4.3E	4Mbps/MSK	TV-V	N	20	1E-05	
4.4.4.4.3E	4Mbps/MSK	TV-V	Y	20	<0E-07	
4.4.4.4.3E	4Mbps/MSK	TV-V	N	10	8E-05	
4.4.4.4.3E	4Mbps/MSK	TV-V	Y	10	-	
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	0	1E-09	3
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	0	1E-09	4
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-1	6E-09	
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-2	1E-08	
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-3	2E-05	
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-4	2E-04	
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-5	5E-04	
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	20	<0E-08	5
4.4.4.4.3F'	4Mbps/QPSK	TV-V	Y	20	<0E-08	2
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	10	<0E-08	5
4.4.4.4.3F'	4Mbps/QPSK	TV-V	Y	10	<0E-08	2
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	0	<0E-08	5
4.4.4.4.3F'	4Mbps/QPSK	TV-V	Y	0	<0E-08	2
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-2	1E-07	5
4.4.4.4.3F'	4Mbps/QPSK	TV-V	Y	-2	<0E-08	2
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-3	5E-06	5
4.4.4.4.3F'	4Mbps/QPSK	TV-V	Y	-3	1E-06	2
4.4.4.4.3F'	4Mbps/QPSK	TV-V	N	-4	2E-04	5
4.4.4.4.3F'	4Mbps/QPSK	TV-V	Y	-4	-	2
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	0	-	6
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	9	0E-07	
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	8	0E-07	
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	7	4E-06	
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	6	1E-04	
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	5	4E-04	
4.4.4.4.4F'	250Kbps/QPSK	TV-V	N	4	-	
4.4.4.4.4J'	250Kbps/QPSK	TV-V	N	0	5E-06	7
4.4.4.4.4J'	250Kbps/QPSK	TV-V	N	9	0E-07	
4.4.4.4.4J'	250Kbps/QPSK	TV-V	N	3	<0E-06	
4.4.4.4.4J'	250Kbps/QPSK	TV-V	N	1	<0E-06	
4.4.4.4.4J'	250Kbps/QPSK	TV-V	N	-1	5E-04	
4.4.4.4.4J'	250Kbps/QPSK	TV-V	N	-3	-	



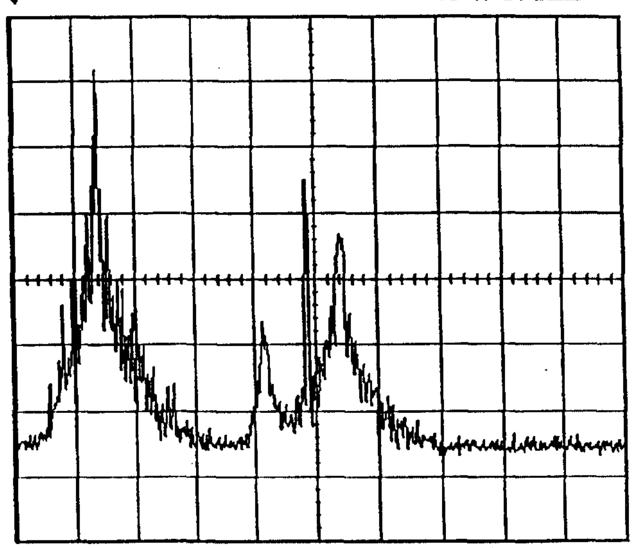
D/U=0 QPSK DATA WITH TV (LOWER CHANNEL) INTERFERENCE
SPECTRAL PLOT 3.4.2.2 A



D/U=0 QPSK DATA WITH TV (LOWER CHANNEL) INTERFERENCE
SPECTRAL PLOT 3.4 .2.2 B



NB QPSK WITH TV (UPPER CHANNEL) INTERFERENCE
SPECTRAL PLOT 3.4.2.2 C



NB QPSK WITH TV (LOWER CHANNEL) INTERFERENCE
SPECTRAL PLOT 3.4.2.2 D

4.0 CONCLUSIONS

All testing was performed in compliance with the Developmental Broadcast Authorization, dated March 10,1998. See Reference E.

4.1 Performance

The conclusions drawn from this testing program on performance issues are as follows with respect to ITFS PACE Digital Data Transmission.

4.1.1 Wideband

The basic wideband transmission characteristics for digital modulations on ITFS channels are summarized below:

- All wideband transmission modes tested- MSK (4 Mbps, 2.7 Mhz) QPSK(4Mbps),OQPSK(4 Mbps), and BPSK(2Mbps)- at full digital power over both point to point links provided excellent bit error rate (BER) performance.
- Regenerative repeating is desired for multi-hop communications as the two multi-hop links tested were sensitive to interference from other ITFS communications channels-probably from the simple custom converter needed to adapt the received RF to the input IF at the hop site.
- Wideband communications link performance for the MSK, QPSK and OQPSK is summarized below. The BER (e.g. 8E-09) is recorded as a function of the transmit power and the resulting S/N.

Table 4.1.1. Wideband Performance

LINK S/N	A (0) S/N=31	A(-14) S/N=17	A(-17) S/N=14	A(-20) S/N=11	C(0) S/N=30	C(-14) S/N=16	C(-20) S/N=10
MSK	8E-09	3E-05	2E-05	7E-05	9E-08	1E-05	NT
QPSK	<0E-09	<0E-08	<0E-08	NT	<0E-08	2E-07	NT
OQPSK	<0E-09	<0E-08	<0E-08	3E-07	4E-08	7E-08	1E-06
NOTES	1. A(0) means full digital power on Link A. Full power resulted in a S/N=31 dB. 2. A(-14) means the digital power on Link A is 14 dB below maximum. Thus S/N=17. 3. Likewise C(0) means full digital power on Link C and a S/N=30 dB. 4. C(-14) means the digital power on Link C is 14 dB below maximum. Thus S/N=16.						

The performance of all modulations was consistent with theory with MSK requiring 3 dB more S/N to achieve the same performance as QPSK or OQPSK.

- Viterbi encoding worked well in the PACE ITFS environment and improved performance by about 4 dB at the expense of ½ the data rate. For example MSK (4 Mbps, 2.7 Mhz) had a 3E-05 BER on Link A at low power. In the same power configuration and MSK (2 Mbps,Viterbi,2.7 Mhz) the BER was 0E-08 –equivalent to about a 4 dB improvement in S/N.

- MSK modulation at 4 Mbps data rate with a frequency deviation of 2.7 Mhz (m=0.675) performed quite acceptably. The transmission spectrum was most compatible with the flat spectrum requirement. The BER performance was as predicted with an increased S/N of 3 dB required for compatible performance with QPSK/OQPSK.
- QPSK modulation at 4 Mbps data rate performed quite acceptably. The transmission spectrum was the standard Sin X/X-truncated by channel filtering. Performance was near theory for the noise environment.
- OQPSK modulation at 4 Mbps data rate performed quite acceptably. The transmission spectrum was the standard Sin X/X-truncated by channel filtering. Performance was near theory for the noise environment.
- Testing clearly supported a 4 Mhz data rate transmission with about a 18dB link margin (15dB for MSK) for maximum digital power.

4.1.2 Narrowband

Narrowband testing was undertaken to support channelization of ITFS signals such that more point to point users could be serviced within the ITFS spectrum. Testing was accomplished at 128 Kbps or 250 Kbps. Maximum power for narrowband was set to that which would be consistent with the power density spectrum of wideband digital communications.

- All narrowband (128 Kbps and 250 Kbps) transmission modes tested- MSK (128 Kbps,100 Khz;250 Kbps,200Khz) QPSK, OQPSK, and BPSK at full narrowband digital power over the Bear Creek to Wolverine point to point link provided excellent bit error rate (BER) performance.
- An older downconverter in the PACE to Bear Creek Link prevented narrowband digital operation. The oscillator stability in the older downconverter was inadequate for narrowband operation. For digital operation these older less stable units should be replaced.
- Multi-hop communications was not successful due to downconverter instability as discussed above. Regeneration repeating would be preferred for narrowband as well as wideband.
- Narrowband communications link performance for the MSK, and QPSK is summarized (BER as a function of transmit power and the resulting S/N) below for Link C with the reference power being that consistent with the wideband spectrum. The performance of all modulations was consistent with theory with MSK requiring 3 dB more S/N to achieve the same performance as QPSK.

Table 4.1.2 Narrowband Performance							
DR	128Kbps				250 Kbps		
POWER	Max	-18 dB	-20 dB	-22 dB	Max	-20	-24
MSK	<0E-07	<0E-07	1E-05	1E-04	<0E-07	4E-05	2E-03
QPSK	<0E-07	<0E-07	<0E-07	1E-06	<0E-07	<0E-07	1E-05
NOTES	1. Max is maximum narrowband power consistent with the maximum wideband spectrum density. 2. –18 dB means 18 dB below the Max of note 1.						

- Viterbi encoding worked well in the PACE ITFS environment and improved performance by about 4 dB at the expense of ½ the data rate. For example MSK (128 Kbps, 100 Khz) had a 2E-03 BER at 23 dB down from full narrowband digital power and a 6E-05 with Viterbi. QPSK at 250 Kbps and 25 dB down from full narrowband power and a 5E-04 BER and a <0E-07 with Viterbi. In both cases the Viterbi provided about a 4 dB improvement in S/N.
- MSK modulation at 250 (or 128) Kbps data rate with a frequency deviation of 200(100) Khz (m=0.80) performed quite acceptably. The transmission spectrum was most compatible with the flat spectrum requirement. The BER performance was as predicted with an increased S/N of 3 dB required for compatible performance with QPSK.
- QPSK modulation at 250(128) Kbps data rate performed quite acceptably. The transmission spectrum was the standard Sin X/X. Performance was near theory for the noise environment.
- OQPSK modulation at 250 (128) Kbps data rate performed quite acceptably. The transmission spectrum was the standard Sin X/X.
- Testing clearly supported a 128 Kbps data rate transmission with about a 20dB link margin (17dB for MSK) for maximum narrowband digital power.
- Operationally and from an interference perspective (See below) narrowband digital operation within the standard ITFS channel is feasible.

4.2 Compatibility

The conclusions drawn from this testing program on FCC related compatibility issues are as follows for the ITFS PACE Digital Data Transmission Initiative.

- The current Desired/Undesired (D/U) interference protection ratio's for cochannel and adjacent channel operations are acceptable for MSK and QPSK type signals.
- The current spectral mask (i.e. –38dB at channel edge and linearly decreasing to –60dB at the middle of the adjacent channel) is acceptable for MSK and QPSK type signals.
- The current overall power constraint of average digital power being equal to or less than the peak video power is acceptable for MSK and QPSK type signals.
- The current requirement for "reasonably flat" spectrum within the digital channel should be changed to the following in order to support low cost modulation forms and channelization.

    - Total digital power within a channel shall be equal to or less than the peak Video power (PVP) allowed. The results in an average spectral density of PVP/6 Mhz. This is the same as currently authorized.
    - Spectral flatness shall be such that nowhere in the channel will the spectral density exceed the average spectral density (PVP/6 Mhz) by 6 dB. This would apply to single or channelized operation.

Documentation from these test results to support these conclusions are summarized below with respect to the current FCC Notice of Proposed Rulemaking, FCC 97-360, dated October 10, 1997:

4.2.1Technical Standard

The contents of paragraphs 4.2.1, 4.2.1.1 through 4.2.1.6 discuss issues directly related to FCC 97-360; Paragraph III, Discussion: subparagraph B.

4.2.1.1 Channelization

The channelization of the ITFS 6 Mhz spectrum is strongly desired by PACE and others. The narrowband testing conducted during this test effort was to demonstrate the benefits and hopefully help influence the direction of the channelization issue. This PACE testing initiative clearly demonstrated that narrowband random digital communications using MSK, QPSK, and OQPSK could be readily accommodated - within the current constraints relative to interference, either cochannel or adjacent - with other TV or digital communications. See paragraph 4.2.2 below for the interference impact. Instead of specifying any general channelization standard, this testing supports a maximum spectral density approach to the channelization. See paragraph 4.2.1.2.3 below.

4.2.1.2 Spectral Mask

4.2.1.2.1 Power Levels

All testing was accomplished using the Peak Visual Power (analog) being equal to the average power level digital as the baseline reference. For our case, this resulted in the wideband digital transmission having a power spectral density of –23dBm/30Khz (BW) relative to a 0 dBm peak visual power. The end result for this situation was that full digital power registered 25% of full Visual power. For performance testing the actual power transmitted was at this level or lower. Testing for interference, in some cases, resulted in this level being exceeded for a short period of time. For narrowband testing, the baseline power spectral density was –23 dBm/30 khz which resulted in the average power level of the digital signal being much less (e.g. –14dB for 250 Khz/6Mhz) than the Peak Visual Power (analog).

4.2.1.2.2 Mask Constraints

The mask constraints require that the spectrum be down 38 dB at channel edge; and uniform attenuation from channel edge to 3 Mhz beyond where –60 dB must be obtained. The prototype modulator driving an existing PACE ITFS Transmitter met these requirements with one minor exception. The clock rate (40 Mhz) of the modulator's digital processor was slightly present at the output of the transmitter (1 Mhz into adjacent channel) and was generally above the specification requirement of –45.3 dB by about 5.5 dB. See Paragraphs A.2, A4, and A5 of Appendix A. This spur will be corrected in the production unit.

4.2.1.2.3 Spectral Flatness

Current guidelines in the Digital Declaratory Ruling is that the spectrum be substantially flat across the band. The MSK signal used in this testing clearly complied with this requirement. The QPSK or OQPSK spectrums used were the standard SIN X/X spectrums. The total power in both the MSK and QPSK modes complied with the Total Video Peak power being equal to the total digital power. The interference test results –See Paragraph 4.2.3 below for MSK and QPSK situations - supports the premise that either the MSK –substantially flat - or the QPSK signal (SIN X/X) can be compatible signals in the ITFS environment to the standard TV transmissions. The narrowband testing, further substantiates that non-substantially flat spectrums may be acceptable. PACE would suggest that the digital transmission spectrum be defined as follows:

- Total digital power within a channel shall be equal to or less than the peak Video power (PVP) allowed. The results in an average spectral density of PVP/6 Mhz (Measured in dBm/Hz) This is the same as currently authorized.

4.2.2 Interference (Digital onto Standard ITFS TV)

Paragraphs 4.2.2, 4.2.2.1 and 4.2.2.2 discuss issues directly related to FCC 97-360; Paragraph III, Discussion: subparagraph C

4.2.2.1 Cochannel Desired/Undesired Ratio

The current requirement of D/U=45 dB cochannel required protection ratio between cochannel TV transmissions is conservative relative to real world in-band digital transmission (with Peak Visual Power (analog) being equal to the average power level digital D/U=0) interference (Undesired) onto analog TV signals (Desired). These results reflect the real world transmission S/N and monitoring environment. However, there is no real need to relax the D/U=45 requirements as this does not realistically affect PACE and other rural ITFS environments. The following data summarizes the worst case results from these ITFS field tests.

TABLE 4.2.2.1 Co-Channel Interference - Digital onto TV

DESIRED	UNDESIRED SIGNAL	D/U RATIO	COMMENTS
TV	4Mbps/MSK	33.5 dB TOV	Threshold of Visibility (TOV) was 36.5 dB or less for the operational link tested. This means that there is an 8.5 Db margin for co-channel interference. Threshold of Audibility (TOA) has 48 dB of margin for co-channel interference.
TV	4Mbps/QPSK	36.5 dB TOV	
TV	4Mbps/MSK	-3 dB TOA	
TV	128Kbps/MSK	35 dB TOV	
TV	128Kbps/QPSK	32 dB TOV	

Additional cochannel interference observations include:

- The level of interference observed for D/U ratios that are 6 dB lower than TOV resulted in CCIR 4 level of interference of "perceptible but not annoying."
- Narrowband cochannel interference D/U ratios were similar even when they were at the most sensitive (e.g. video carrier or color carrier) interference frequency.

The conclusion concerning cochannel interference for MSK and QPSK signals wideband (e.g. 4 Mbps) or narrowband (e.g. 250 Kbps)--and their derivatives (e.q. OQPSK) is that the current D//U=45 dB interference protection ratio for cochannel communications is quite adequate and should be acceptable for any class of signals where the power spectral density meets the current digital definitions of peak Video power greater than or equal to average digital power of a full bandwidth signal.

4.2.2.2 Adjacent Channel Desired/Undesired Ratio

The current adjacent D/U interference protection ratio is 0 dB. The following data summarizes the worst case results from our ITFS tests.

TABLE 4.2.2.2 Adjacent Channel Interference - Digital onto TV			
DESIRED	UNDESIRED SIGNAL	D/U RATIO	COMMENTS
TV	4Mbps/MSK	-3 TOV	Summary of worst case adjacent (upper, lower or upper/lower) channel interference in a real world environment. CCIR4 performance was at least 6 dB greater than TOV thus, providing a margin to the D/U=0 of at least 6 dB.
TV	4Mbps/QPSK	-5 TOV	
TV	4Mbps/MSK	<-10 TOA	
TV	4Mbps/QPSK	<-10 TOA	
TV	128Kbps/MSK	-3 TOV	
TV	250Kbps/QPSK	-1 TOV	

The conclusion concerning adjacent channel interference for MSK and QPSK signals wideband (e.g. 4 Mbps) or narrowband (e.g. 250 Kbps)–and their derivatives (e.g. OQPSK) is that the current D//U=0 dB interference protection ratio for cochannel communications is adequate and should be acceptable for any class of signals where the power spectral density meets the current digital definitions of peak Video power greater than or equal to average digital power of a full bandwidth signal.

4.3 Interference (Standard ITFS TV onto Digital)

4.3.1 Cochannel Desired/Undesired Ratio

The current requirement of D/U=45 dB cochannel required protection ratio between cochannel TV transmissions is conservative relative to real world digital transmission (with Peak Visual Power (analog) being equal to the average power level digital D/U=0) (Desired) with in band analog TV interference signals (Undesired). These results reflect the real world transmission S/N and monitoring environment. However, there is no real need to relax the D/U=45 requirements as this probably will not realistically affect PACE and other rural ITFS environments as they implement digital communications on ITFS. The following data summarizes the worst case results (BER about 10E-06) from these ITFS field tests.

TABLE 4.3.1 Cochannel Interference - TV onto Digital			
DESIRED	UN DESIRED	D/U RATIO	COMMENTS
4Mbps/MSK	TV	30	With a D/U=45 there is a minimum of 8 dB margin and this is for the worst case narrowband where the narrowband desired signal is on top of the video carrier from the undesired TV signal.
4Mbps/QPSK	TV	17	
4Mbps/OQPSK	TV	16	
128Kbps/MSK	TV	37	
128Kbps/QPSK	TV	32	

4.3.2 Adjacent Channel Desired/Undesired Ratio

The current adjacent D/U interference protection ratio is 0 dB. The following data summarizes the worst case results (BER about 10E-06) from our ITFS tests.0

TABLE 4.3.2 Adjacent Channel Interference - TV onto Digital			
DESIRED	UN DESIRED	D/U RATIO	COMMENTS
4Mbps/MSK	TV	30	Summary of worst case adjacent (upper, or) channel interference of TV onto digital in a real world environment. (vc) means that the video carrier is close to the narrowband digital data. (ac) means it's the audio carrier being close to the narrowband digital data.
4Mbps/QPSK	TV	-2	
250Kbps/QPSK	TV	7 (vc)	
250Kbps/QPSK	TV	0 (ac)	

The results concerning adjacent channel interference for TV interference with MSK signals wideband (e.g. 4 Mbps) show that the prototype ITFS receiver for this modulation does not provide adequate dynamic range or FM demodulation performance to operate satisfactorily with the D/U=0 dB interference protection ratio. Wideband QPSK will work satisfactorily. Narrowband QPSK near the video carrier frequency is about 7 dB from working with D/U=0. Improved dynamic range will solve this problem. Note the acceptable performance of the narrowband QPSK near the audio carrier (15 dB below the problem video carrier).

These test results do not justify any change to the adjacent channel interference protection ratio of D/U=0 dB. The digital receive equipment must be designed to reject the adjacent channels with a D/U=0 situation thus permitting adjacent Digital/TV usage in the same user environment.

5.0 RECOMMENDATIONS

5.1 FCC

Present this report to the FCC for their consideration in finalizing the rules for ITFS digital data transmission. Specific data is presented in Paragraph 4.2 concerning FCC issues. There are three recommendations based upon the conclusions.

- This testing clearly demonstrates that MSK, QPSK and OQPSK wideband modulations can be effectively utilized for digital data transmission without causing any adverse effects to ITFS communications. Recommend that MSK, QPSK, OQPSK or any other modulation meeting the spectral characteristics defined below be approved.
- This testing clearly demonstrates that MSK, QPSK and OQPSK narrowband modulations can be effectively utilized for digital data transmission without causing any adverse effects to ITFS communications. Recommend that channelization of any ITFS channel be approved as long as the spectrum characteristics defined below be approved.
- PACE would suggest that the digital transmission spectrum be defined as follows:
    - Total digital power within a channel shall be equal to or less than the peak Video power (PVP) allowed. This results in an average spectral density of PVP/6 Mhz (dBm/Hz) for the digital modulation. This is the same as currently authorized.
    - The "substantially flat" spectrum requirement be defined as follows "Spectral flatness shall be such that no where in the channel will the spectral density exceed the average spectral density (PVP/6 Mhz) by 6 dB. This would apply to single or channelized operation"

5.2 PACE

Test results have clearly supported the PACE objectives for utilization of ITFS resources for meeting school/staff wideband data communications needs. Results were exceptional in that wideband downstream communications using any of three modulations over four different PACE links were successfully demonstrated. For upstream communications, narrowband transmissions were readily supported as long as the downconverters were stable. All waveforms were demonstrated to be consistent with FCC requirements and none caused interference when the current desired/undesired (D/U) interference protections were satisfied. The existing PACE ITFS Infrastructure will readily new digital communications capabilities. This successful test program results in the following recommendations.

ITFS/MMDS PACE INITIATIVE

TEST REPORT
for
DIGITAL DATA TRANSMISSION
INTERNET TO THE SCHOOLS
FIELD TESTS

APPENDIX A
SUMMARY OF LABORATORY TEST RESULTS

A.1. Scope

The scope of this Appendix is to summarize the results of the Laboratory Testing accomplished in support of the ITFS/PACE Initiative. Laboratory testing of the following Summation Research, Inc. (SRI) developed hardware was accomplished.

- ITFS Digital Data Demodulator (ITFS DDD)
- ITFS Digital Data Modulator (ITFS DDM)

Laboratory testing of PACE inventory ITFS equipment was accomplished.

- SB25- 25Watt Channel A2 Transmitter
- R50A/SB50A Channel C2 Repeater Transmitter
- Receiver Channel C2

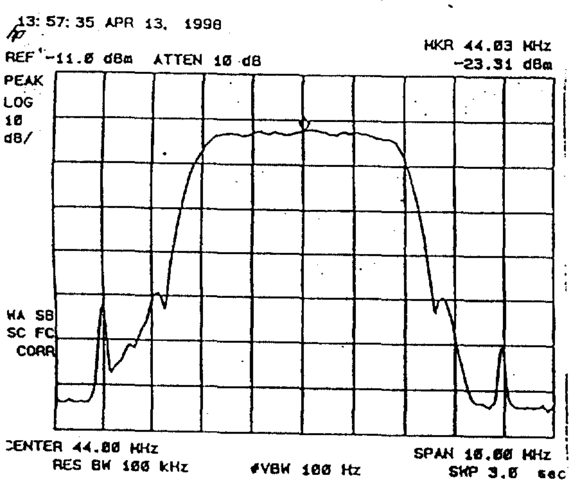
TABLE A.1 EQUIPMENT UNDER TEST			
EQUIPMENT	SERIAL NUMBER	EQUIPMENT	SERIAL NUMBER
ITFS DDM	001	SB-025A CH A2	00097
ITFS DDD	001	SB-050A CH C2	00108
		R50A CH C2	00105
		Receiver CH C2	00111

A.2. ITFS Digital Data Modulator (ITFS DDM)

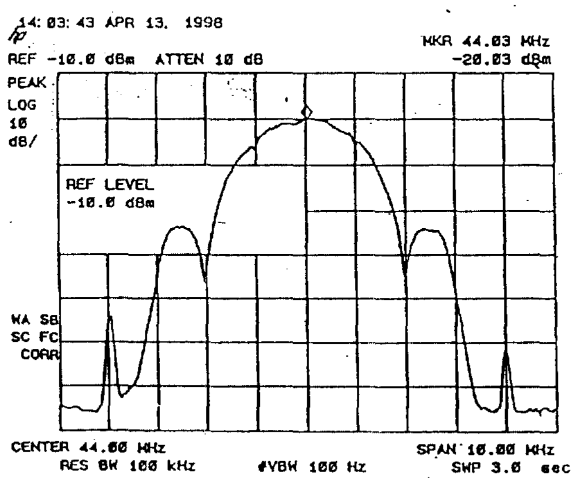
The ITFS Digital Data Modulator (ITFS DDM) was tested standalone. Its spectral output and power levels were measured using random data inputs at 4Mbps and 128 Kbps rate. Spectrum and power of all four (MSK,OQPSK, QPSK, and BPSK) output modulation modes were documented. A summary of the test result follow.

The spectrum plots of 4 Mbps data rates for MSK and QPSK/OQPS modulations are shown below. The output is centered at 44 Mhz. That is the input center frequency for the ITFS transmitters used in the testing. The waveforms meet the FCC spectrum mask with the exception of the 40 Mhz clock coupling which will be corrected in production.

OUTPUT ITFS DDM



MSK



QPSK/OQPSK

Total power output with RF2 set to +9 is –5.7 dBm for MSK, or –5.4 dBm for QPSK or OQPSK. The output power will reduce in 1 dB steps from RF2=+9. For example, RF2=0 would result in output power of –14.7 dBm MSK and –14.4 dBm for QPSK or OQPSK.